Mapping Coarse Fragment Variability of Stony Soils Through Electromagnetic Induction

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Introduction

The high variability of coarse fragments in soil causes spatial and temporal variability of soil water content and complex soil-vegetation dynamics (Tokumoto, 2013). Measuring soil water content in soils with coarse fragments is problematic because rocks physically hinder the insertion of probes, volumetric samplers, and other measuring tools. Coarse fragments even affect non-invasive measurements such as the cosmic-ray soil moisture observing system (COSMOS) because the presence of rocks should decrease the signal. Non-invasive electromagnetic induction (EMI) is commonly used for mapping soil properties including water content, clay content, and salinity (Corwin and Lesch, 2001) and we expect EMI may be able to map coarse fragments because similar geophysical techniques have shown a response to rocks in the soil matrix (Rey et al., 2006; Rossi et al., 2013). The ability to map coarse fragments would lead to a better understanding of soil-water dynamics in these soils and may improve calibration procedures for COSMOS and other similar surface sensors.

Objectives

1. Determine the dominant soil properties driving the EMI response in soils with coarse fragments (rocky soil).
2. Investigate the ability of EMI to map the spatial extent of coarse fragments.

Fig. 1 Profile of the Rumple gravelly clay loam at the Freeman Ranch Center of Texas State University near San Marcos, Texas. Photo taken by Dr. Ieyasu Tokumoto.

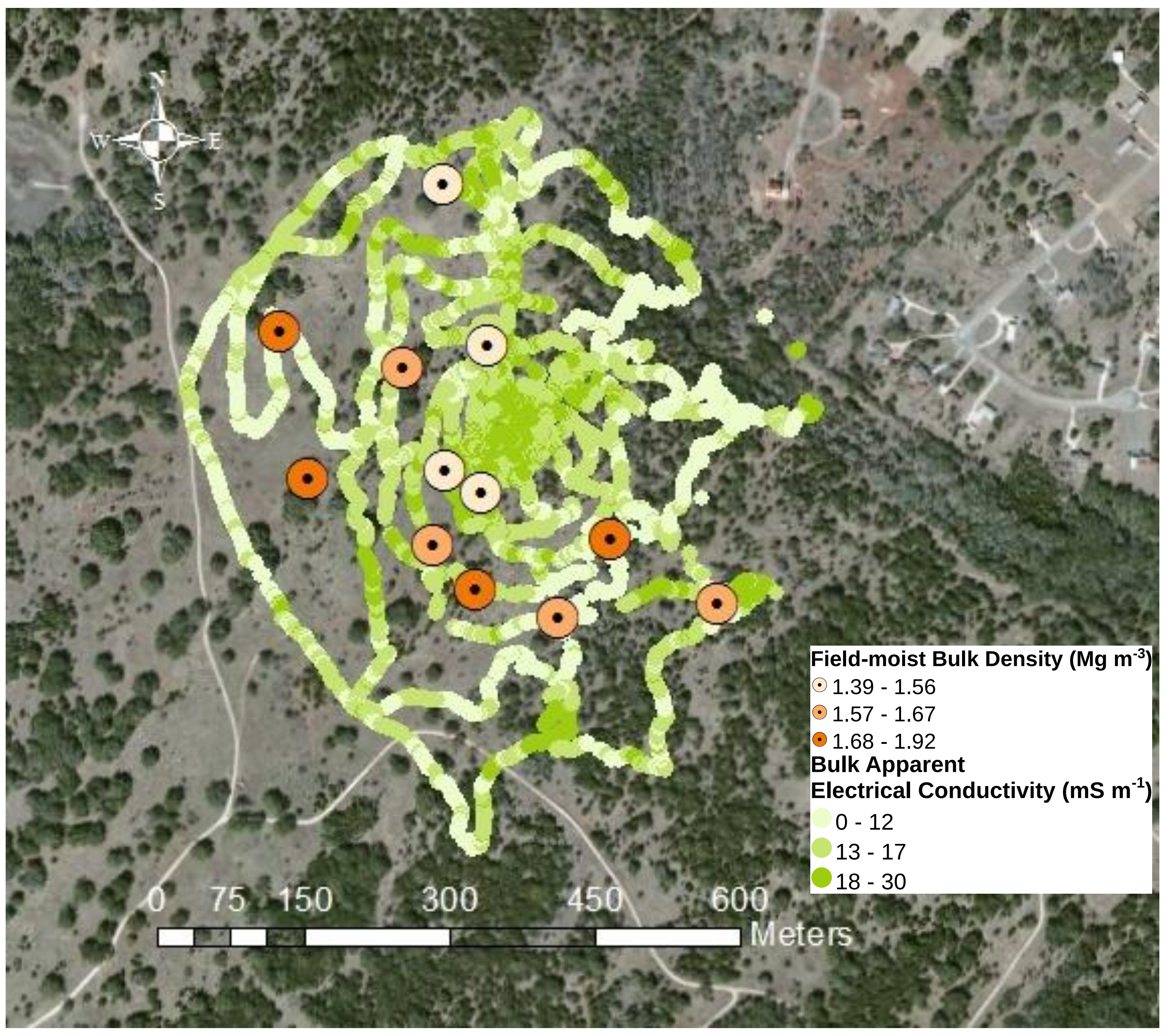
Materials and Methods

The area of interest is the effective area of a COSMOS probe located on the Freeman Ranch Center of Texas State University outside of San Marcos, Texas. The mean surface clay content of the Rumple series is 25% with chert and limestone parent material occurring at 50 to 65 cm with coarse fragments throughout the profile.

- EMI Survey: An EMI survey of the area was conducted with an EM38 MK2 (Geonics LTD, Ontario, Canada) on March 14, 2015 (Fig. 2).
- Gravimetric Water Content: Samples were collected from 48 locations across the site at three depth intervals: 0 to10, 10 to 20, and 20 to 30 cm. Samples were taken at 10, 20, 40, 80, 160, and 320 m from the COSMOS probe along 8 equally-spaced radial arms.
- Bulk Density: Field-moist bulk density was measured using a volume replacement method. Sampling sites were determined by using stratified random sampling. Four measurements from three zones were taken.

Fig. 2 Conducting an EMI survey..

Results and Discussion



Field-moist Bulk Density (Mg m^{-3})
- ● 1.39 - 1.56
- ● 1.57 - 1.67
- ● 1.68 - 1.92

Bulk Apparent Electrical Conductivity (mS m^{-1})
- ● 0 - 12
- ● 13 - 17
- ● 18 - 30

Fig. 3 The EM survey of the effective area of the COSMOS probe.

- The observed response of the EMI survey followed patterns in the vegetation with lower EC_a values in areas with high tree density (Fig. 3).
- The bulk density values were negatively correlated with EC_a (Fig. 4).
- EC_a was not well correlated with gravimetric water content (Fig. 5).
- It is expected that increasing bulk density values should correspond with higher coarse fragment content due to the decreased porosity of coarse fragments when compared to the soil matrix.

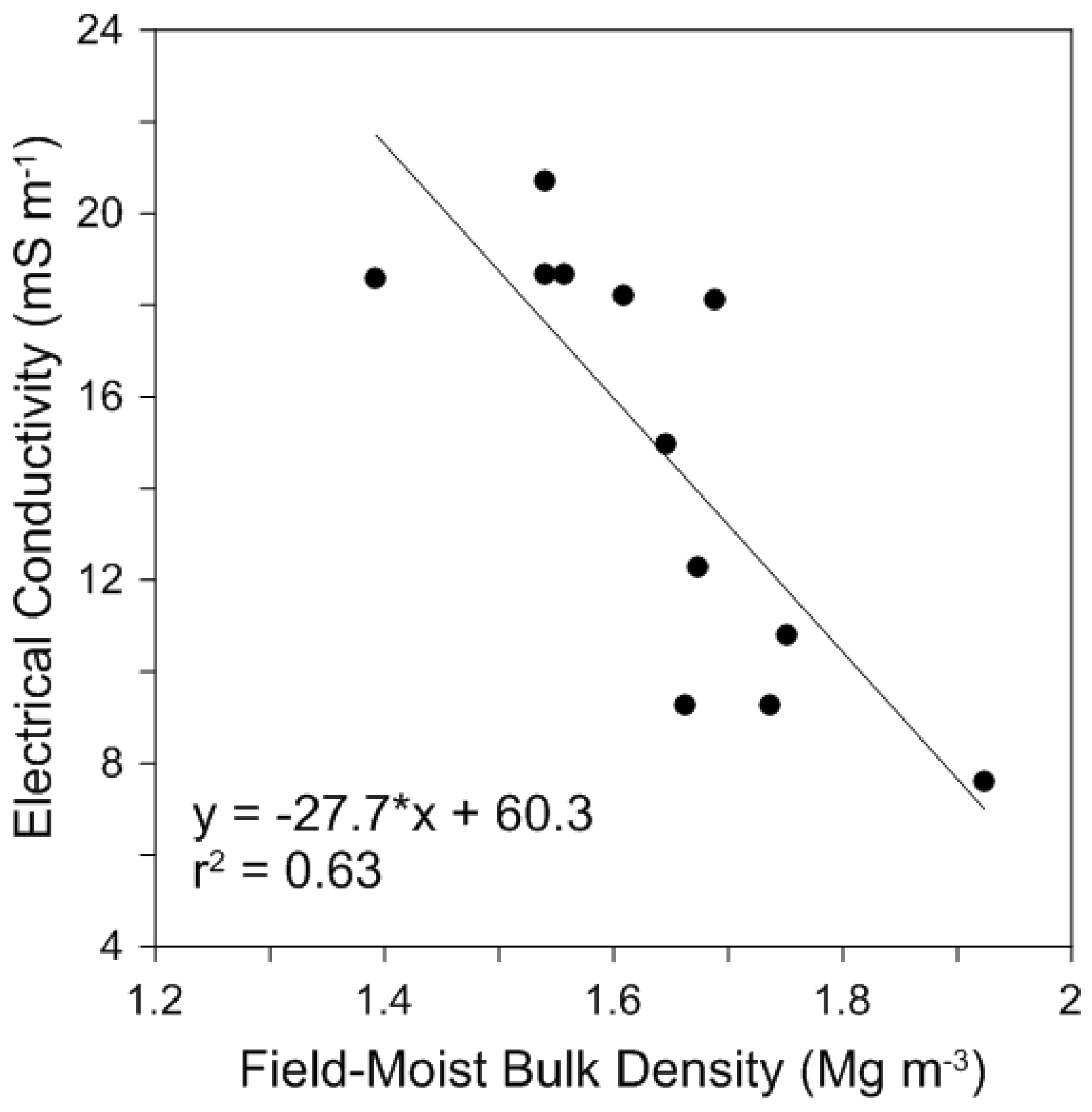


Fig. 4 Correlation of field-moist bulk density measurements with apparent electrical conductivity.

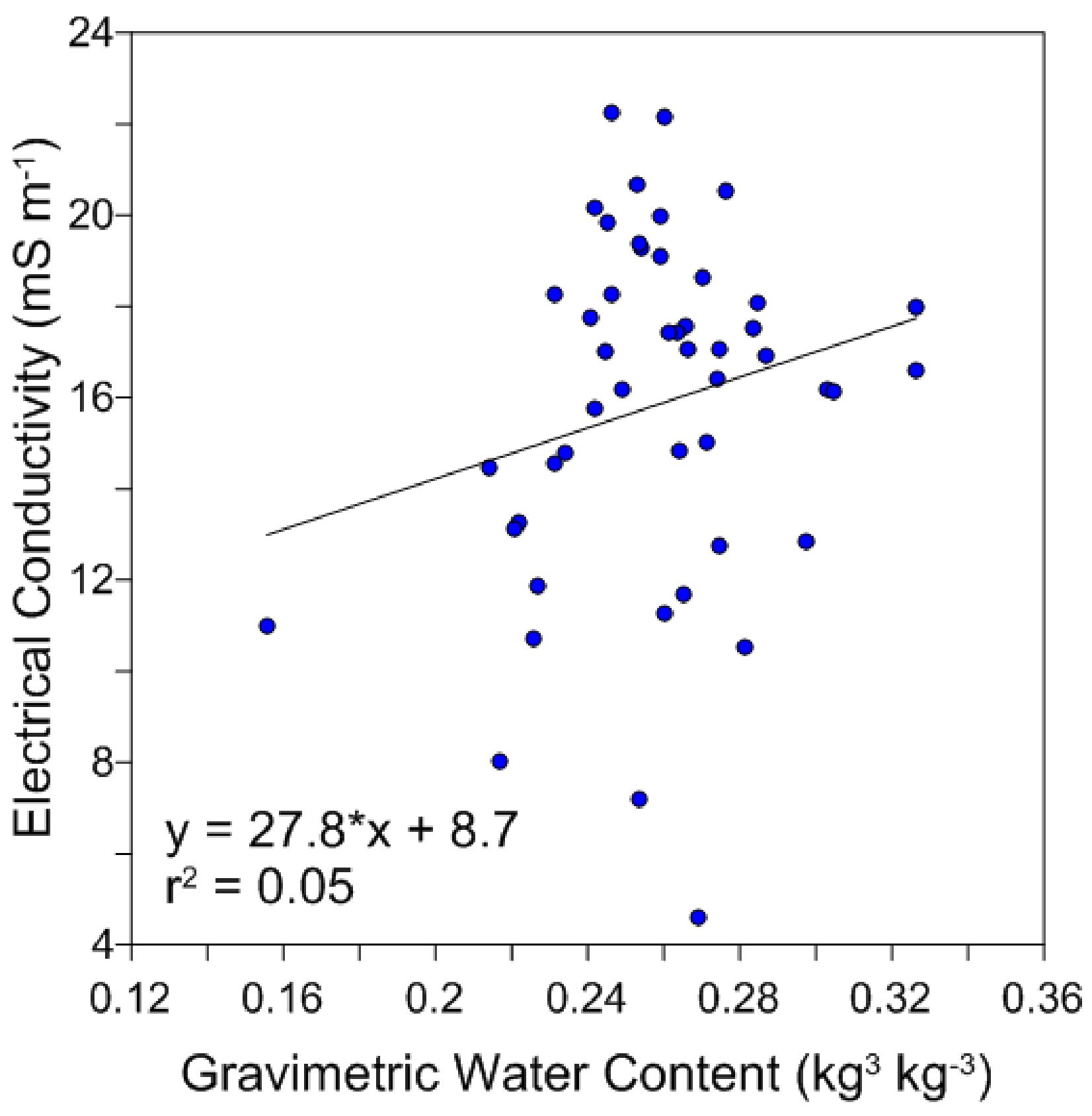


Fig. 5 Correlation of gravimetric water content measurements with apparent electrical conductivity.

The Next Step

- The next step is to measure the coarse fragment content of both the bulk density samples and the gravimetric water content samples.
- Conduct subsequent surveys of the site at different water contents.

References

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